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# Discussion paper

## ***BASIC VERSUS SUPPLEMENTARY HEALTH INSURANCE: MORAL HAZARD AND ADVERSE SELECTION***

by  
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# Basic versus supplementary health insurance: moral hazard and adverse selection\*

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## Abstract

This paper introduces a tractable model of health insurance with both moral hazard and adverse selection. We show that government sponsored universal basic insurance should cover treatments with the biggest adverse selection problems. Treatments not covered by basic insurance can be covered on the private supplementary insurance market. Surprisingly, the cost effectiveness of a treatment does not affect its priority to be covered by basic insurance.

**Keywords:** universal basic health insurance, voluntary supplementary insurance, public vs private insurance, adverse selection, moral hazard, cost effectiveness

**JEL classification:** I13, D82, H51

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## 1. Introduction

This paper considers a health insurance system where the government sponsors universal basic health insurance and private parties offer voluntary supplementary insurance. The question we analyze is: which treatments should be covered by insurance and how (i.e. basic vs supplementary insurance)?

A well known intuition is that basic insurance can battle adverse selection problems but not moral hazard. In the words of Cutler and Zeckhauser (2000, pp. 588): “Moral hazard is a significant concern in insurance policies but it is not one that necessarily argues for government intervention. Government insurance policies ... may engender just as much moral hazard as private insurance policies”. Universal basic insurance by being applied to everyone can overcome adverse selection. This reasoning implies that basic insurance should cover treatments that suffer most from adverse selection. However, the literature on cost effectiveness analysis (see, for instance, Drummond et al., 2005; Gold et al., 1996, for overviews) suggest that the government should give priority to treatments that give the highest health gain per euro spent and cover these by basic insurance.

To analyze this question, we extend the Rothschild and Stiglitz (1976) (RS) insurance model to include moral hazard and a number of different treatments. We show that a welfare maximizing government covers treatments by basic insurance where the adverse selection problems are biggest. Neither moral hazard nor (surprisingly) cost effectiveness affect the priority of a treatment for coverage by basic insurance. That is, moral hazard plays no role in whether (*extensive* margin) or how a treatment should be insured. Co-payments for a treatment increase and hence insurance decreases (*intensive* margin) if it suffers more from moral hazard. We come back to cost effectiveness in the conclusion. Further, the analysis shows that efficient health care consumption is not necessarily welfare maximizing. And the generosity of basic insurance is affected by whether or not the government can force private insurers to set efficient co-payments.

The reason to combine public and private insurance is given by the imperfections in the private health insurance market (Blomqvist, 2011; Zweifel, 2011). Public and private health insurance can be combined in a number of ways. We consider the case where private insurance is bought to cover treatment for conditions that are not covered by public insurance. One can think of dental care, physiotherapy and prescription glasses that are not covered by the public insurance system. But, also, the public system may not fully cover the costs of a treatment and people can insure the public co-payment on the private market. Examples of this combination of public and private insurance include the Netherlands (after 2006), France and Luxembourg (Mossialos and Thomson, 2004, pp. 39-41). The Patient Protection and Affordable Care Act (“Obamacare”) is also a move in this direction. Ten essential health benefits categories are defined that need (at least) to be covered by health insurance. It is left to the states to define which treatments within these categories will be covered exactly (McDonough, 2011). People are free to buy more coverage if they want, but any health insurance contract needs to cover at least the basics.<sup>1</sup> So which treatments belong to the basics?

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<sup>1</sup>Two other ways in which private and public insurance can be combined are the following. First, private insurance may substitute for public insurance. That is, people are either covered privately or publicly. This is the case in Australia, Ireland, Spain and used to be the case in the Netherlands before 2006 (Colombo and Tapay, 2004, pp. 14). Second, private insurance is bought in addition to public insurance to get faster access (i.e.

We analyze the case with universal public coverage for a basic insurance package. There is a fixed budget to finance the public system; hence not all treatments can be covered by basic insurance. The private market (as in RS) features second degree price discrimination and hence there are inefficiencies due to selection incentives. The question is: which conditions should be covered by public insurance and which treatments can be left to the private market? We denote insurance offered by the private voluntary market: supplementary insurance.<sup>2</sup>

This paper is related to three strands of literature. First, from a technical point of view, we analyze a two tiered problem similar to DeMarzo et al. (2005) and Faure-Grimaud et al. (1999). In our case, the government sets parameters for basic insurance which then affect the equilibrium interaction between insurers and consumers on the private market. The health insurance context is similar to Bijlsma et al. (forthcoming), but they consider the effects of risk adjustment in a private insurance market; not the distinction between private and public insurance.

Second, there is the (health) insurance literature on adverse selection. A seminal paper is RS: insurers separate customer types by offering efficient insurance for high risk types and a contract with under-insurance for low risk types. This under-insurance is the inefficiency of the market outcome. Dahlby (1981) is an early paper showing potential benefits of a combination of public and voluntary private insurance. However, the analysis in this literature is not done at the treatment level. That is, it does not answer the question how a treatment should be insured. Models in this literature generally ignore over-consumption of health care due to insurance.

Third, there is an extensive literature on moral hazard in health insurance. We discuss this literature under two headings. First, the literature that considers optimal coverage at the treatment level. This literature does not consider the public-private split of insurance coverage. Second, we discuss papers that do consider public vs. private insurance, but not at the treatment level.

The classic result on the degree of coverage at the treatment level is the trade off between risk sharing and excess demand for the treatment (moral hazard). The co-payment for treatment  $k$  should be higher the smaller the financial risk imposed by  $k$  and the more elastic the demand for  $k$ . Pauly (1968) and Zeckhauser (1970) are seminal papers. Using empirical estimates of demand elasticities for health services, Manning and Marquis (1996) find optimal co-insurance rates of almost 50%. The literature then moved away from the case of a single health care service to analyze interdependencies in demand for health care services. Besley (1988) derives a Ramsey pricing intuition for the optimal co-payment for treatment  $k$ . Goldman and Philipson (2007) argue that if the use of a certain drug saves on hospital costs (substitute treatments), the optimal co-payment on the drug is low even though its demand may be quite elastic. With complementary treatments, the optimal co-payment is higher than the elasticity would suggest. Ellis et al. (2011) extend this idea to multiple states of the world and multiple time periods.

This literature tends to define moral hazard in the following way. Consider a treatment  $k$  that an agent uses if it is covered by health insurance but does not use if she would pay the full costs of  $k$  herself (Cutler and Zeckhauser, 2000, pp. 576). Then treatment  $k$  is seen as over-consumption induced by moral hazard of insurance. We show that this definition can be misleading in the sense that this type of moral hazard can be efficient (in the sense of welfare

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shorter waiting lists), have a broader choice of providers and treatments for a given condition. Examples include Austria, Denmark and Finland (Mossialos and Thomson, 2004, pp. 38/9).

<sup>2</sup>Sometimes this is called complementary insurance (see Mossialos and Thomson, 2004, pp. 16).

maximizing).

We conclude with three papers on the split between public and private health insurance. Blomqvist and Johansson (1997) consider a model with only moral hazard. They show that a mixed public-private health insurance system is less efficient than a purely private system. The reason is the externality between the insurance systems: increasing coverage in one system raises the expected costs in the other system. In our model, the government takes this into account when designing the public system. Further, in our model the government can repair another market imperfection: adverse selection. Coate (1995) analyzes mandatory public insurance in the light of the Samaritan's dilemma. Altruistic rich agents give the poor money to buy private health insurance. The poor underinvest in insurance, hoping that the rich will help them once treatment is needed (Samaritan's dilemma). By making insurance mandatory, the underinvestment in insurance is avoided. Finally, Petretto (1999) analyzes a system with optimal constant co-insurance rates<sup>3</sup> for public and private insurance in a system with linear taxation. None of these papers answers the question that we are interested in: which treatments should be covered by public and which by private insurance?

Our paper is organized as follows. The next section introduces a model where people buy health insurance because they are risk averse. Then we explain the basic and supplementary insurance set up of the model. Section 4 gives the details of the insurance contracts used. Then we characterize the market equilibrium in the supplementary market. Section 6 derives which treatments should be covered by basic insurance. Proofs can be found in the appendix.

## 2. Model with adverse selection and moral hazard

This section presents a model of health insurance: a risk averse agent buys insurance to reduce consumption risk. The market imperfections are adverse selection and moral hazard.<sup>4</sup> We derive efficient health care consumption and the co-payments needed to get to this efficient outcome.

### 2.1. utility

People are risk averse and therefore buy health insurance. We capture this here by using a simple mean-variance utility structure. Models with both adverse selection and moral hazard tend to become technical (see for example Laffont and Martimort, 2002, chapter 7) but mean-variance utility allows a tractable analysis. An agent with expected health  $v$ , expected expenditure  $E(x)$  and variance in expenditure  $V(x)$  has utility equal to

$$U = v - E(x) - \frac{r}{2}V(x) \quad (1)$$

where  $r$  measures the degree of risk aversion. An advantage of mean-variance utility is that total welfare and efficiency are the same. There are no distributional concerns (as would be introduced by a concave utility function to represent risk aversion).<sup>5</sup>

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<sup>3</sup>Much of the moral hazard literature assumes a constant co-insurance rate. That is, the insurer reimburses a constant fraction of health care expenditure. An exception is Blomqvist (1997).

<sup>4</sup>We use "moral hazard" here in the health economics sense of excessive care consumption.

<sup>5</sup>See Boone (2014) for an analysis of redistributive concerns in the context of basic vs supplementary insurance.

## 2.2. treatments

The set of conditions (“illnesses”) is denoted  $K = \{1, 2, \dots, \kappa\}$ . For each condition  $k \in K$  we assume that there is exactly one treatment (the one that is most cost effective); also denoted by  $k$ .<sup>6</sup> There are two types of agents, denoted  $h, l$ . The probability that agent of type  $j \in \{l, h\}$  needs treatment  $k$  is denoted by  $\theta_k^j$  where we assume that

$$\theta_k^l \leq \theta_k^h \leq \frac{1}{2} \quad (2)$$

for each  $k \in K$ .<sup>7</sup> Hence, high risk types have a (weakly) higher probability –compared to low risk types– that they need treatment  $k \in K$ . The fraction of  $\theta^l[\theta^h]$  types is denoted by  $\phi[1 - \phi]$ .

We assume that conditions are contractible. That is, a physician can determine whether or not a patient suffers from condition  $k$  and needs treatment  $k$ .<sup>8</sup> An insurer or the planner can verify this information. Hence, there is no moral hazard on what treatment is needed. However, we do consider moral hazard on the intensity of the treatment. Intensity of treatment can refer to either quantity (like more sessions of physiotherapy) or quality (more expensive/higher dose) of treatment. Below we refer to treatment intensity as quality. There is a probability  $\psi_k[1 - \psi_k]$  (the same for the  $h$  and  $l$  type, to ease notation) that the patient is in state 0[1]. The utility gain of the low [high] quality treatment  $k$  in state  $s$  is denoted by  $\underline{v}_{sk}[\leq \bar{v}_{sk}]$ ,  $s \in \{0, 1\}$ . The cost of the low [high] treatment equals  $\underline{\delta}_k[\leq \bar{\delta}_k]$  independent of the state  $s \in \{0, 1\}$  and type  $j \in \{h, l\}$ . We make the following assumptions:

$$\begin{aligned} \underline{v}_{1k} &= 0 \\ \bar{v}_{1k} - \bar{\delta}_k &> 0 \\ \underline{v}_{0k} - \underline{\delta}_k &\geq 0 \\ \bar{v}_{0k} - \underline{v}_{0k} &< \bar{\delta}_k - \underline{\delta}_k \end{aligned} \quad (3)$$

In words, in state 1 only the high quality treatment can cure condition  $k$  and doing this is cost effective (gain in utility exceeds the costs of the treatment). In state 0, the low quality treatment is cost effective. To illustrate, the low quality treatment can be simply to do nothing ( $\underline{v}_{0k} = \underline{\delta}_k = 0$ ). Using the high quality treatment in state 0 is not cost effective: the additional cost (compared to the low quality treatment) exceeds the utility gain. However, a fully insured patient prefers the h-treatment because  $\bar{v}_{0k} \geq \underline{v}_{0k}$ . We assume that the patient can reveal the state 0 or 1 by truthfully reporting her symptoms to her physician. However, she can also exaggerate her symptoms to qualify for the high quality treatment. Put differently, whereas we assume that the condition is contractible, the severity of the condition is not verifiable/contractible.

Equation (3) shows that there is a role for cost-effectiveness (CE) analysis in health insurance. Only treatments where the value  $v$  exceeds the cost  $\delta$  should be covered by insurance. Although the costs  $\delta$  of a treatment are fairly straightforward to determine, quantifying the

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<sup>6</sup>We focus on “ex post” treatments. For an analysis of ex ante measures (prevention), see Ellis and Manning (2007).

<sup>7</sup>Equation (2) makes sure that high types face a higher variance in health expenditure than low types. This leads to a consistent ranking of types. See Boone and Schottmüller (2013) for an analysis of the case where types are not ranked consistently because the single crossing assumption is not satisfied.

<sup>8</sup>Alternatively, treatment  $k$  for a patient suffering from  $k' \neq k$  yields zero utility.



benefits  $v$  is not so obvious. This is usually done in terms of quality adjusted life years (so-called, qaly's). See, for instance, Drummond et al. (2005) and Gold et al. (1996) for methods to determine the value of treatments.

Although books on CE analysis do not usually distinguish between public and private insurance, it seems fair to say that their policy implication is that public insurance should focus on treatments that are most cost effective.<sup>9</sup> In our set up, this implies that basic insurance should cover treatments  $k$  in state  $s$  with the highest  $v_{sk}/\delta_{sk}$ . However, proposition 2 below implies that higher cost effectiveness of a treatment does not raise the priority of this treatment for basic insurance.

### 2.3. efficient care consumption

Note that equation (3) allows for a formal definition of moral hazard: health care consumption that is socially inefficient. In particular, the use of the high quality treatment in state 0. It is this moral hazard risk of over-consumption that prevents full insurance from being socially efficient ex post. Note that treatments where the severity is actually contractible can be represented as having  $\bar{v}_{0k} = \underline{v}_{0k}$ : patients have no incentive to lie about the state  $s$ .

We use

$$\Delta v_k \equiv \bar{v}_{0k} - \underline{v}_{0k} \quad (4)$$

as a measure of moral hazard. The higher  $\Delta v_k$ , the more treatment  $k$  suffers from moral hazard.

We assume that the risks for the different conditions  $k \in K$  are independently distributed.<sup>10</sup> Assume that agent of type  $j \in \{l, h\}$  has bought private insurance at premium  $\sigma$ . This insurance leads the agent to get treatment with utility  $v_{sk}$  at social cost  $\delta_{sk}$  in state  $s$  of condition  $k$  with out-of-pocket expenditure (co-payment) for the agent equal to  $c_{sk}$ .<sup>11</sup> Then expected utility of type  $j$  using utility function (1) can be written as

$$U^j = \sum_{k \in K} U_k^j - \sigma \quad (5)$$

with

$$\begin{aligned} U_k^j &= (1 - \theta_k^j)v_k + \theta_k^j(\psi_k(v_{0k} - c_{0k}) + (1 - \psi_k)(v_{1k} - c_{1k})) \\ &\quad - \frac{1}{2}r (\theta_k^j\psi_k c_{0k}^2 + (1 - \psi_k)\theta_k^j c_{1k}^2 - (\theta_k^j\psi_k c_{0k} + \theta_k^j(1 - \psi_k)c_{1k})^2) \end{aligned} \quad (6)$$

where the variance term on the second line follows from lemma 1 in appendix A.<sup>12</sup> With probability  $1 - \theta_k^j$ , agent  $j$  does not suffer from condition  $k$  and utility equals  $v_k$ . With probability  $\theta_k^j\psi_k$  agent  $j$  suffers from  $k$  in state 0; treatment gives utility  $v_{0k}$  at out-of-pocket cost (co-payment)  $c_{0k}$ . In state 1, treatment gives utility  $v_{1k}$  at co-payment  $c_{1k}$ .

<sup>9</sup>To illustrate, if CE analysis were to seriously advice private insurers, it should address selection issues. Neither Drummond et al. (2005) nor Gold et al. (1996) have the words “adverse selection” in their index.

<sup>10</sup>For an analysis of correlated conditions and treatments, see Ellis et al. (2011).

<sup>11</sup>This is a slight abuse of notation. If  $\hat{s}$  denotes a patient's report of  $s$ , we should write  $v_{\hat{s}k}, \delta_{\hat{s}k}, c_{\hat{s}k}$ . But as we focus on the case where agents truthfully reveal  $s$ , we keep notation “light” by writing  $s$  directly.

<sup>12</sup>In particular, substitute  $x = c_{0k}, y = c_{1k}, z = 0$  and probabilities:  $\zeta = \theta_k^j\psi_i, \xi = \theta_k^j(1 - \psi_i)$  in equation (A.1).



Assumption (3) implies that ex post a patient in state 0 (1) should get the low (high) quality treatment. With an actuarially fair premium, the following inequality implies that also ex ante it is socially efficient to induce efficient ex post consumption:

$$\begin{aligned}
& (1 - \theta_k^j)v_k + \theta_k^j(\psi_k(\bar{v}_{0k} - \bar{\delta}_k) + (1 - \psi_k)(\bar{v}_{1k} - \bar{\delta}_k) - \frac{1}{2}rc_{0k}^2\theta_k^j(1 - \theta_k^j) < \\
& (1 - \theta_k^j)v_k + \theta_k^j(\psi_k(\underline{v}_{0k} - \underline{\delta}_k) + (1 - \psi_k)(\bar{v}_{1k} - \bar{\delta}_k) \\
& - \frac{1}{2}r(\theta_k^j\psi_kc_{0k}^2 + (1 - \psi_k)\theta_k^j(c_{0k} + \Delta v_k)^2 - (\theta_k^j)^2(c_{0k} + (1 - \psi_k)\Delta v_k)^2)
\end{aligned} \tag{7}$$

at  $c_{0k} = \underline{\delta}_k$  for each  $k \in K, j \in \{l, h\}$ . It is readily verified that equation (7) holds for each  $c_{0k} \in [0, \underline{\delta}_k]$  if it holds at  $c_{0k} = \underline{\delta}_k$ . In words, suppose that there is a co-payment equal to  $c_{0k}$  for the low quality treatment of condition  $k$ . Then a planner can decide to minimize the risk for the agent and set a co-payment equal to  $c_{0k}$  for the high quality treatment as well. This leads to inefficient consumption (as the agent will claim to be in state 1 all the time) at a cost for society equal to  $\theta_k^j\bar{\delta}_k$ . Alternatively, the planner can induce efficient care consumption by setting the co-payment in state 1 equal to  $c_{0k} + \Delta v_k$ . This leads to lower expected costs but higher variance. Assumption (7) says that ex ante the agent prefers the higher variance and efficient consumption over the case with inefficient care consumption.

If equation (7) would not be satisfied, a social planner maximizing welfare would not induce efficient care consumption. That is, from an ex ante perspective it is more efficient to insure the agent (against higher costs in state 1) than to induce efficient care consumption. Arguably, in this case there is no inefficient care consumption in a second best sense. Hence, as discussed in the introduction, the definition of moral hazard used in the health economics literature can be misleading. Using the high quality treatment in state 0 only happens if it is insured: moral hazard but actually (ex ante) efficient.

From now onward, we follow the literature and assume that (7) holds for every treatment  $k \in K$ : both ex post and ex ante welfare is maximized by inducing efficient care consumption. Given the current policy emphasis on efficient care consumption this seems to be the relevant case.<sup>13</sup>

Equation (7) implies that a competitive supplementary insurance market (without basic insurance) offers efficient insurance. Indeed, with an actuarially fair premium for each type (i.e. price equal to marginal cost), consumer value is maximized by offering insurance which induces ex post efficient health care consumption. Hence, consumers buying insurance prefer (ex ante) contracts inducing efficient care consumption. However, if full insurance would be offered (inefficiently) a patient will prefer (ex post) to use high quality treatment in state 0.

## 2.4. efficient co-payment

As the state is private information for the agent, the efficient treatment choice can only be induced by having an additional co-payment for the high quality treatment (compared to the low treatment) that is at least equal to  $\Delta v_k$ :

$$c_{1k} \geq c_{0k} + \Delta v_k \tag{8}$$

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<sup>13</sup>Allowing for the case where (7) is not satisfied for some treatments is straightforward in the analysis below but a bit tedious notation wise. There would then be a set of conditions  $K'$  where the high intensity treatment is used in both states 0 and 1. The efficient co-payment for treatments in  $K'$  would be zero etc. Allowing for this does not affect the main result (proposition 2) which is based on an envelop argument.

If the agent in state 0 lies about the state by exaggerating symptoms in order to get the high quality treatment, she gets utility

$$\bar{v}_{0k} - c_{1k} \leq \underline{v}_{0k} - c_{0k} \quad (9)$$

Hence, the agent has no incentive to lie about the state.

### 3. Basic and supplementary insurance

Basic health insurance works as follows. If treatment  $k$  in state  $s$  is covered by basic insurance, the cost of this treatment for the market is reduced from  $\delta_{sk}$  to  $\gamma_{sk}$ . If a patient is not insured, she pays  $\gamma_{sk}$  when she needs the treatment. An insured patient pays  $\gamma_{sk}$  in two parts. First, as co-payment  $c_{sk}$  when she uses the treatment and, second, in the form of a (actuarially fair) premium  $\theta_k^j \psi_{sk}(\gamma_{sk} - c_{sk})$  where  $\psi_{sk} = \psi_k[1 - \psi_k]$  in state  $s = 0[1]$ .

With  $\gamma_{sk} = \delta_{sk}$ , treatment  $k$  in state  $s$  is not covered by basic insurance. With  $\gamma_{sk} = c_{sk}$ , treatment  $k$  in state  $s$  is completely covered by basic insurance (in the sense that no private insurance is involved).<sup>14</sup>

Without basic insurance, equation (7) implies that the market offers efficient insurance (preventing over-consumption in state 0) if exclusionary contracts can be used. That is, an insurer can exclude a customer from contracting with another insurer. If an insurer cannot prevent the consumer from contracting with another insurer, the market may not be able to sustain the efficient outcome. See, for instance, Pauly (1974) and Kahn and Mookherjee (1998) for an analysis of this case.

We assume that the market can enforce that a consumer contracts with (at max.) one private insurer. That is, the number of insurers with whom an agent contracts is verifiable in court. An insurance contract becomes void if it turns out that the agent has contracted with more than one insurer.

We further assume that

**GE** the government can enforce co-payments  $c_{0k}, c_{1k}$  set by private insurers to induce efficient health care consumption (i.e. satisfy (9)).

The issue here is that equation (7) is assumed to hold with costs  $\delta_{sk}$ ; it does not necessarily hold with costs  $\gamma_{sk} < \delta_{sk}$ . Within the supplementary market this problem is avoided by assuming that an agent can contract with one insurer only. However, the point of basic insurance is that it is not exclusive; the agent is expected to buy supplementary insurance. GE implies that the government can choose  $\gamma_{sk}$  without worrying about efficient health care consumption.<sup>15</sup> This implies that  $\gamma_{0k}, \gamma_{1k}$  satisfy

$$\gamma_{1k} \geq \gamma_{0k} + \Delta v_k \quad (10)$$

The case where GE is not satisfied is denoted GN. Here we follow the GE case. Appendix A.2 analyzes the case where the government cannot enforce efficient co-payments by private

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<sup>14</sup>If  $\gamma_{sk} > c_{sk}$ , consumers can buy supplementary insurance to cover the difference  $\gamma_{sk} - c_{sk}$  (recall from the introduction that supplementary insurance allows private insurers to cover part of the “public co-payment”  $\gamma_{sk}$ ).

<sup>15</sup>Countries that have regulation like this include Canada, Japan and Sweden (Blomqvist, 2011; Colombo and Tapay, 2004).

insurance. The main result (proposition 2 below) holds in both cases. For a given government budget, with GN basic insurance is less generous per treatment but more treatments are covered by basic insurance.

#### 4. Insurance contracts

In the market outcome, we consider an equilibrium where insurers compete in bundles. That is, they offer insurance contracts with coverage for all treatments simultaneously. In particular, they do not compete in contracts that cover only one treatment. This is a natural choice in this context for several reasons. First, to prevent that one insurer over-insures the customer of another insurer we assume that a customer can only buy from one insurer.<sup>16</sup> Second, with second degree price discrimination, an insurer wants to offer a contract targeted at each type  $h$  and  $l$ . This is most efficiently done in a bundle. Suppose insurers sell two contracts for each treatment that consumers want covered by supplementary insurance and each of these contract pairs is incentive compatible (i.e.  $l$ -type chooses one contract and  $h$ -type chooses the other). Then bundling all  $l$ -contracts together in contract L and all  $h$ -contracts together in contract H will lead to two contracts that are incentive compatible as well. As incentive compatibility leads to distortions (under-insurance for the  $l$ -type; see below), it may be possible to smooth distortions in the bundled contract better than in the contracts per treatment (which each separately needs to be incentive compatible). Hence the insured do not lose and may strictly gain from the bundled contracts.

Therefore, we focus on the case where each insurer offers two contracts only. One contract targeted at the  $l$ -type and one contract targeted at the  $h$ -type. We focus on second degree price discrimination: insurers cannot risk rate.<sup>17</sup> There may be two reasons for this. Either, insurers lack the information to risk rate at the moment an agent buys insurance. Or, insurers do have this information but are not allowed to use it; the government imposes community rating in the supplementary market.

We assume that the supplementary insurance market is perfectly competitive. We follow the RS definition of the perfect competition equilibrium: (i) each offered contract makes non-negative profits and (ii) given the equilibrium contracts there is no other contract yielding positive profits.<sup>18</sup>

#### 5. Market equilibrium

As is well known (see, for instance, RS), the binding incentive compatibility constraint is that the  $h$ -type should not prefer to buy the  $l$ -contract. Since the  $l$ -type does not want to

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<sup>16</sup>If insurers would sell insurance per condition and consumers were allowed to mix and match, one would need to check whether for each such contract there was an overlap with the contract of another insurer to avoid over-insurance. This would lead to higher transaction costs than is the case where a consumer buys (all) supplementary insurance from one insurer. Moreover, even in the case where insurance could be sold per condition there is still an equilibrium in which each insurer only sells a bundle. This can be seen as follows. If insurer  $j$ 's competitors only sell bundles which cover all treatments,  $j$ 's best reply is to sell a bundle as well.

<sup>17</sup>Appendix A.1 considers the case where risk rating is allowed.

<sup>18</sup>In RS an equilibrium may not exist if the fraction of  $\theta^l$ -types is large. This paper does not focus on existence of equilibrium. Implicitly, we assume that the fraction of  $\theta^l$ -types is small enough that an equilibrium exists.

mimic the  $h$ -type (we check this below), we know from the RS analysis that the contract for the  $h$ -type is undistorted. That is, this contract is efficient. This implies that  $c_{0k}^h = 0$  for each  $k \in K$ . Further, given that the government wants to induce efficient care consumption, efficient supplementary insurance implies  $c_{1k}^h = \Delta v_k$ . The insurance market provides maximum insurance for  $h$  subject to efficient care consumption.

In order to avoid  $h$ -types buying the  $l$ -contract, the  $l$ -contract features under-insurance:  $c_{0k}^l > 0, c_{1k}^l > \Delta v_k + c_{0k}^l$  for some treatments  $k \in K$ .

In order to find which treatments should be covered by basic insurance, we need to characterize the equilibrium outcome in the supplementary market. It turns out that for our purposes we do not need to explicitly solve for the equilibrium in the supplementary market.

First, we introduce some notation. Given that  $c_{0k}^h = 0, c_{1k}^h = \Delta v_k$ , we can write utility for the  $h$ -type as:

$$U^h(\gamma) = \sum_{k \in K} U_k^h(\gamma) - \sigma^h(\gamma) \quad (11)$$

where

$$U_k^h(\gamma) = (1 - \theta_k^h)v_k + \theta_k^h(\psi_k \underline{v}_{0k} + (1 - \psi_k)(\bar{v}_{1k} - \Delta v_k)) - \frac{1}{2}r(\Delta v_k)^2(1 - \psi_k)\theta_k^h(1 - (1 - \psi_k)\theta_k^h) \quad (12)$$

$$\sigma^h(\gamma) = \sum_{k \in K} \theta_k^h(\psi_k \gamma_{0k} + (1 - \psi_k)(\gamma_{1k} - \Delta v_k)) \quad (13)$$

In words, expected utility for  $h$  type equals the sum of expected utilities for each condition  $k$  as given by (6). The premium equals the expected expenditure minus the efficient co-payments paid by  $h$ .

Whereas  $c_{0k}^h, c_{1k}^h$  are fixed at the efficient level, this is not necessarily the case for the  $l$  type. We define the following vector:

$$c^l = \{(c_{0k}^l, c_{1k}^l)\}_{k \in K} \quad (14)$$

For the  $l$ -type we have

$$U^l(c^l, \gamma) = \sum_{k \in K} U_k^l(c^l, \gamma) - \sigma^l(c^l, \gamma) \quad (15)$$

where

$$U_k^l(c^l, \gamma) = (1 - \theta_k^l)v_k + \theta_k^l(\psi_k(\underline{v}_{0k} - c_{0k}^l) + (1 - \psi_k)(\bar{v}_{1k} - c_{1k}^l)) - \frac{1}{2}r(\theta_k^l\psi_k(c_{0k}^l)^2 + (1 - \psi_k)\theta_k^l(c_{1k}^l)^2 - (\theta_k^l\psi_k c_{0k}^l + \theta_k^l(1 - \psi_k)c_{1k}^l)^2) \quad (16)$$

and

$$\sigma^l(c^l, \gamma) = \sum_{k \in K} \theta_k^l(\psi_k(\gamma_{0k} - c_{0k}^l) + (1 - \psi_k)(\gamma_{1k} - c_{1k}^l)) \quad (17)$$

In order to write down the incentive compatibility constraint for the  $h$ -type ( $IC_h$ ), we introduce  $\hat{U}^h$  which is the utility for the  $h$ -type of buying the  $l$ -contract (mimicking the  $l$  type):

$$\hat{U}^h(c^l, \gamma) = \sum_{k \in K} \hat{U}_k^h(c^l, \gamma) - \sigma^l(c^l, \gamma) \quad (18)$$

where  $\sigma^l(c^l, \gamma)$  is the premium given in (17) and

$$\hat{U}_k^h(c^l, \gamma) = (1 - \theta_k^h)v_k + \theta_k^h(\psi_k(\underline{v}_{0k} - c_{0k}^l) + (1 - \psi_k)(\bar{v}_{1k} - c_{1k}^l)) - \frac{1}{2}r(\theta_k^h\psi_k(c_{0k}^l)^2 + (1 - \psi_k)\theta_k^h(c_{1k}^l)^2 - (\theta_k^h\psi_k c_{0k}^l + \theta_k^h(1 - \psi_k)c_{1k}^l)^2) \quad (19)$$

For a mimicking  $h$  type, the probability of actually needing treatment  $k$  in either state 0 or 1 and paying co-payment  $c_{0k}^l, c_{1k}^l$  resp. is given by  $\theta_k^h$ ; although the premium is based on  $\theta_k^l$ . Thus, the gain from mimicking for  $\theta^h$  is of the form  $(\theta_k^h - \theta_k^l)(\gamma_k - c_k)$ . Raising co-payment  $c_k$  helps insurers to separate the types (as in RS). This is the way that the market deals with adverse selection problems.

The government has another instrument to battle selection. Reducing the treatment costs  $\gamma_k$  by covering the treatment with basic insurance, makes mimicking less attractive. Hence insurers need to distort less to get separation. This is the welfare gain that the government is after.

The  $h$  type has no incentive to mimic the  $l$  type if

$$U^h(\gamma) \geq \hat{U}^h(c^l, \gamma) \quad (IC_h)$$

The following proposition summarizes the RS equilibrium for this situation: efficient insurance for the  $h$ -type and under-insurance for the  $l$ -type. That is, the market offers the  $l$ -type its utility maximizing insurance subject to the incentive compatibility constraint of the  $h$ -type.

**Proposition 1** *If an equilibrium exists in the RS game, it features  $c_{0k}^h = 0, c_{1k}^h = \Delta v_k$  for each  $k \in K$ . Insurance premium  $\sigma^h$  is given by equation (13). For the  $l$ -type  $c_{0k}^l, c_{1k}^l$  solve the following maximization problem:*

$$U^l(\gamma) = \max_{c_{0k}^l \geq 0, c_{1k}^l \geq c_{0k}^l + \Delta v_k} U^l(c^l, \gamma) + \nu(U^h(\gamma) - \hat{U}^h(c^l, \gamma)) \quad (20)$$

where  $\nu$  denotes the Lagrange multiplier on  $(IC_h)$  constraint. Premium  $\sigma^l$  is given by equation (17).

This gives an implicit characterization of the market equilibrium. A more explicit characterization is not straightforward. Fortunately, for our purposes, the implicit characterization is sufficient to find which treatments should be covered by either basic or by supplementary insurance.

## 6. Optimal government policy

Given the equilibrium in the supplementary market, how does the government choose its parameters of basic insurance  $\gamma_{0k}, \gamma_{1k}$  to maximize total welfare? Clearly, the government's choice of  $\gamma_{sk}$  affects the equilibrium outcome in the supplementary market.<sup>19</sup> We assume that the government has a budget  $B \geq 0$  that it can spend on basic insurance.

Government expenditure  $E$  is given by

$$E(\gamma) = \sum_{k \in K} (\phi \theta_k^l + (1 - \phi) \theta_k^h) (\psi_k (\underline{\delta}_k - \gamma_{0k}) + (1 - \psi_k) (\bar{\delta}_k - \gamma_{1k})) \quad (21)$$

where

$$\gamma = \{(\gamma_{0k}, \gamma_{1k})\}_{k \in K} \quad (22)$$

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<sup>19</sup>Note that basic insurance here is subsidized ( $\gamma_{0k} \leq \underline{\delta}_k, \gamma_{1k} \leq \bar{\delta}_k$ ) and hence taken up voluntarily by agents. Hence, in this model there is no need to make basic insurance mandatory.

Government solves optimization problem:

$$\max_{\gamma_{0k} \leq \underline{\delta}_k, \gamma_{1k} \leq \bar{\delta}_k \text{ subject to (10)}} \phi U^l(\gamma) + (1 - \phi) U^h(\gamma) - \mu(E(\gamma) - B) \quad (23)$$

where the utilities of  $h$  and  $l$  types,  $U^h(\gamma)$ ,  $U^l(\gamma)$ , are defined by equations (11,20) and  $\mu$  denotes the Lagrange multiplier on the government's budget constraint  $E(\gamma) \leq B$ .

Now we can prove the following proposition.

**Proposition 2** *Rank treatments such that*

$$\theta_1^h/\theta_1^l \geq \theta_2^h/\theta_2^l \geq \dots \geq \theta_\kappa^h/\theta_\kappa^l$$

*Starting at treatment 1 and then moving to treatment 2 etc. the government sets  $\gamma_{0k} = 0$  and  $\gamma_{1k} = \Delta v_k$ . This goes on until the budget  $B$  is spent.*

The priority for covering treatments by basic insurance is determined by the adverse selection problems associated with treatments. The difference in risk between types is higher –and therefore the adverse selection problems are more severe– for treatments  $k$  with high  $\theta_k^h/\theta_k^l$ . The proposition says that such treatments should be financed via basic insurance, not via supplementary insurance. This is intuitive, as universal basic insurance can mitigate adverse selection problems. By lowering  $\gamma_{sk}$  for treatment  $k$  the effect of  $\theta_k^h - \theta_k^l$  is reduced. This relaxes the incentive compatibility constraint for the  $h$ -type ( $IC_h$ ) and hence reduces the distortion of under-insurance for the  $l$ -type. This reduction in the distortion (and hence increase in welfare) is bigger, the bigger is  $\theta_k^h/\theta_k^l$ .

Second, moral hazard plays no role at all in deciding which treatments to insure nor in the decision how to insure. A treatment with  $\Delta v_k = 0$  does not suffer from moral hazard at all. While a treatment with high  $\Delta v_k$  suffers from major moral hazard problems. But  $\Delta v_k$  plays no role in proposition 2. As basic insurance is plagued by moral hazard to the same extent as the supplementary market, this is not a deciding factor in allocating a treatment to either basic or supplementary insurance. On the extensive margin, moral hazard does not affect whether a treatment is covered in supplementary insurance either (as all treatments in  $K$  are covered by either basic or supplementary insurance).

On the intensive margin, a treatment with high  $\Delta v_k$  is covered to a smaller extent in both basic and supplementary insurance. The higher  $\Delta v_k$  is, the higher the co-payment in state 1 (equation (8)).

Finally, the value of treatments  $v_{sk}$  plays no role at all in the government's decision which treatments to cover under basic insurance (except that the high quality treatment is not covered in state 0). The intuition for this is as follows. Agents can afford any treatment that they want to buy. All treatments in the set  $K$  are “worth it” in the sense that value/utility created is higher than the cost of the treatment if the intensity is adjusted to the state of the patient (see (3); treatments where the cost exceeds the utility gain can be deleted from  $K$  without loss of generality). Hence, insurance is only about costs and the reduction in income risk. The value of treatments plays no role: there is no sense in which treatments with higher CE scores  $v/\delta^{20}$  have higher priority to be covered either in basic or supplementary insurance.

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<sup>20</sup>Or equivalently, lower CE ratios,  $\delta/v$ , measuring the cost per qaly gained.



## 7. Conclusion

A number of countries feature a combination of public basic insurance and private supplementary insurance. A model based on moral hazard and adverse selection suggests that basic insurance should cover treatments that suffer most from adverse selection. This formalizes a well known intuition that the government can improve the market outcome by solving adverse selection problems. However, both the government and the market suffer from moral hazard and hence moral hazard plays no role when deciding whether or not a treatment should be covered by basic insurance.

The model here suggests that cost effectiveness of treatments plays no role in prioritizing treatments for coverage in basic insurance. To the extent that we believe that moral hazard and adverse selection are the main problems in health insurance, this implies that basic insurance should focus on treatments with serious adverse selection issues. Treatments for chronically ill come to mind, like people with diabetes, rheumatoid arthritis, Alzheimer, Parkinson etc. The treatments for these diseases –covered by basic insurance– need to be cost effective. But there is no sense in which higher cost effectiveness increases the priority for a treatment to be covered by basic insurance. Basic insurance should cover the treatments where the inefficiencies in the supplementary market are highest.

In a sense, this is surprising as many governments use cost effectiveness to prioritize treatments for inclusion in basic health insurance (Thomson et al., 2012; Gold et al., 1996; Drummond et al., 2005). In a companion paper, Boone (2014), we analyze the case where people buy insurance to guarantee access to care. That is, they face a budget constraint that makes it impossible to pay for expensive treatments without health insurance. Nyman (1999) is an early reference stressing the importance of the access to care motive of health insurance. We analyze which treatments should be covered by basic and which by supplementary insurance in an access to care model. Then cost effectiveness plays a natural role in prioritizing treatments for basic and supplementary insurance. Further, in such a model redistributive concerns also affect the set of treatments to be covered by basic insurance.

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## A. Proof of results

The variance term in equation (6) follows from the following lemma.

**Lemma 1** *Consider random variable  $X$  which takes on the values  $x$  with probability  $\zeta \geq 0$ ,  $y$  with probability  $\xi \geq 0$  and  $z$  with probability  $1 - \zeta - \xi \geq 0$ . Then the variance of  $X$  is given by*

$$V(x) = \zeta(x - z)^2 + \xi(y - z)^2 - (\zeta(x - z) + \xi(y - z))^2 \quad (\text{A.1})$$

**Proof of lemma 1** The expectation of  $X$  equals

$$E(X) = \zeta x + \xi y + (1 - \zeta - \xi)z$$

Hence the variance equals

$$\begin{aligned} V(X) &= \zeta(\xi^2(y - z)^2 + (1 - \zeta)^2(z - x)^2 + 2\xi(1 - \zeta)(y - z)(z - x)) \\ &\quad + \xi(\zeta^2(x - z)^2 + (1 - \xi)^2(z - y)^2 + 2\zeta(1 - \xi)(x - z)(z - y)) \\ &\quad + (1 - \zeta - \xi)(\zeta^2(x - z)^2 + \xi^2(y - z)^2 + 2\zeta\xi(x - z)(y - z)) \\ &= \zeta(1 - \zeta)(x - z)^2 + \xi(1 - \xi)(y - z)^2 - 2\zeta\xi(x - z)(y - z) \\ &= \zeta(x - z)^2 + \xi(y - z)^2 - (\zeta(x - z) + \xi(y - z))^2 \end{aligned}$$

*Q.E.D.*

**Proof of proposition 1** The proof follows directly from RS. The one thing we need to check is that  $\theta^l$  does not want to mimic  $\theta^h$ :  $U^l(c^l, \gamma) \geq \hat{U}^l(\gamma)$  where  $\hat{U}^l$  denotes the utility of  $\theta^l$  when buying the  $h$ -contract. We consider two cases. First,  $\nu = 0$ : then both contracts are efficient and  $l$  has no incentive to mimic  $h$  (in fact, in this case,  $h$  will want to mimic  $l$ , contradicting  $\nu = 0$ ). Second,  $U^h(\gamma) = \hat{U}^h(c^l, \gamma)$ . We show by contradiction that  $\theta^l$  does not want to mimic  $\theta^h$ . That is, suppose –by contradiction– that

$$\hat{U}^l > U^l(c^l, \gamma) \quad (\text{A.2})$$

Combining this inequality with  $U^h(\gamma) = \hat{U}^h(c^l, \gamma)$  gives

$$\begin{aligned} 0 &> \sum_{k \in K} \Delta\theta_k (\psi_k c_{0k}^l + (1 - \psi_k)(c_{1k}^l - \Delta v_k)) \\ &\quad + \frac{1}{2}r \left[ \theta_k^h \psi_k (c_{0k}^l)^2 + (1 - \psi_k) \theta_k^h (c_{1k}^l)^2 - (\theta_k^h)^2 (\psi_k c_{0k}^l + (1 - \psi_k) c_{1k}^l)^2 - (\Delta v_k)^2 (1 - \psi_k) \theta_k^h (1 - (1 - \psi_k) \theta_k^h) \right. \\ &\quad - \left( \theta_k^l \psi_k (c_{0k}^l)^2 + (1 - \psi_k) \theta_k^l (c_{1k}^l)^2 - (\theta_k^l)^2 (\psi_k c_{0k}^l + (1 - \psi_k) c_{1k}^l)^2 \right. \\ &\quad \left. \left. - (\Delta v_k)^2 (1 - \psi_k) \theta_k^l (1 - (1 - \psi_k) \theta_k^l) \right) \right] \quad (\text{A.3}) \end{aligned}$$

The first line on the right side is positive as  $\Delta\theta_k \geq 0$  and  $c_{1k}^l - \Delta v_k \geq c_{0k}^l \geq 0$  for each  $k$  because of (8). Hence, we get the desired contradiction if the expression in square brackets is positive. A sufficient condition for this is:

$$\frac{d}{d\theta} (\theta \psi c_0^2 + (1 - \psi) \theta c_1^2 - \theta^2 (\psi c_0 + (1 - \psi) c_1)^2 - (\Delta v)^2 (1 - \psi) \theta (1 - (1 - \psi) \theta)) \geq 0 \quad (\text{A.4})$$

where we have dropped superscripts and subscripts where this does not cause confusion. Or equivalently,

$$\psi c_0^2 + (1 - \psi)c_1^2 - 2\theta(\psi c_0 + (1 - \psi)c_1)^2 \geq (\Delta v)^2(1 - \psi)(1 - 2(1 - \psi)\theta) \quad (\text{A.5})$$

First, note that the left hand side is increasing in  $c_1$ :

$$2(1 - \psi)c_1 - 4\theta(1 - \psi)(\psi c_0 + (1 - \psi)c_1) \geq 0 \quad (\text{A.6})$$

This can be seen as follows. The expression is decreasing in  $\theta$ . Hence, it holds for all  $\theta \leq \frac{1}{2}$  (see equation (2)) if it holds at  $\theta = \frac{1}{2}$ :  $c_1 \geq \psi c_0 + (1 - \psi)c_1$  which is true because  $c_1 \geq c_0$ .

Therefore, equation (A.5) holds, if it holds at  $c_1 = c_0 + \Delta v$ ; this can be written as

$$\psi c_0^2 + (1 - \psi)(c_0 + \Delta v)^2 - 2\theta(c_0 + (1 - \psi)\Delta v)^2 \geq (\Delta v)^2(1 - \psi)(1 - 2(1 - \psi)\theta) \quad (\text{A.7})$$

This holds with equality at  $c_0 = 0$ . Hence, it holds for all  $c_0 \geq 0$ , if the derivative of the left hand side with respect to  $c_0$  is positive:

$$2\psi c_0 + 2(1 - \psi)(c_0 + \Delta v) - 4\theta(c_0 + (1 - \psi)\Delta v) \geq 0 \quad (\text{A.8})$$

Again note that the left hand side is decreasing in  $\theta$ . Thus, the inequality holds for all  $\theta \leq \frac{1}{2}$  if it holds at  $\theta = \frac{1}{2}$ :

$$2c_0 + 2(1 - \psi)\Delta v - 2(c_0 + (1 - \psi)\Delta v) \geq 0 \quad (\text{A.9})$$

which holds indeed. Hence, equation (A.5) holds and we get the desired contradiction. It follows that  $\theta^l$  does not want to mimic  $\theta^h$ . *Q.E.D.*

**Proof of proposition 2** The  $h$ -type wants to mimic the  $l$ -type, but not the other way around. Hence we can use proposition 3 in appendix B: we only need to consider the direct effects of  $\gamma_{sk}$  on welfare in (23). Hence we find that

$$\begin{aligned} \frac{dW}{d\gamma_{sk}} &= \phi \frac{\partial U^l}{\partial \gamma_{sk}} + (1 - \phi) \frac{\partial U^h}{\partial \gamma_{sk}} - \mu \frac{\partial E}{\partial \gamma_{sk}} \\ &= -\psi_{sk} (\phi(\theta_k^l + \nu \Delta \theta_i) + (1 - \phi)\theta_k^h - \mu(\phi\theta_k^l + (1 - \phi)\theta_k^h)) \end{aligned}$$

where  $\psi_{0k} = \psi_k$ ,  $\psi_{1k} = 1 - \psi_k$  and  $\Delta \theta_k = \theta_k^h - \theta_k^l$ . Note that this derivative does not depend on  $\gamma_{sk}$ ; that is,  $W$  is linear in  $\gamma_{sk}$ . Therefore, we get a bang-bang solution where  $\gamma_{sk}$  takes on either the lowest possible or highest possible value. For  $\gamma_{0k}$  this can be written as

$$1 + \phi \nu \frac{\Delta \theta_k}{\phi \theta_k^l + (1 - \phi) \theta_k^h} \begin{cases} \geq \mu & \text{then } \gamma_{0k} = 0 \\ < \mu & \text{then } \gamma_{0k} = \underline{\gamma}_k \end{cases} \quad (\text{A.10})$$

Hence, if the value of reducing  $\gamma_{0k}$  exceeds the cost,  $\mu$ , of such a reduction, planner chooses the lowest possible  $\gamma_{0k}$ . If the value of such a reduction is lower than the cost, the planner does not cover treatment  $k$  in state 0:  $\gamma_{0k} = \underline{\gamma}_k$ . When treatment  $k$  is the last one before the budget  $B$  is spent, the cost of a further reduction in  $\gamma_{0k}$  equals the benefit exactly when the last euro of  $B$  is spent. In this case, government covers treatment  $k$  with probability  $\rho_k^g \in \langle 0, 1 \rangle$ . Its complement  $1 - \rho_k^g$  can be covered by supplementary insurance.

The expression for  $\gamma_{1k}$  is similar to (A.10), except that  $\gamma_{1k} = \bar{\delta}_k$  if the cost of reducing  $\gamma_{1k}$  exceeds the benefit and  $\gamma_{1k} = \gamma_{0k} + \Delta v_k$  if the benefits exceed the costs.

Note that  $\phi, \mu$  and  $\nu$  in equation (A.10) are the same for each treatment  $k \in K$ . Hence treatments  $k$  with the highest left hand side in equation (A.10) are covered by basic insurance. It is routine to verify that these are the treatments with highest values for  $\theta_k^h / \theta_k^l$ . *Q.E.D.*

### A.1. Third degree price discrimination

With third degree price discrimination, the market outcome does not feature inefficiencies. Each contract has efficient insurance:  $c_{0k} = 0, c_{1k} = \Delta v_k$ . The  $h$ -type pays a higher (actuarially fair) premium than the  $l$ -type. But recall that the planner does not care about distribution. Hence, the planner is indifferent which treatments to cover in basic insurance. Any subset of treatments that satisfy the government budget constraint is optimal from the planner's point of view.

### A.2. Efficient care consumption

In the main text, we assume that the government can enforce the level of co-payments  $c_{sk}$  set by private insurers. The government then dictates co-payments that induce efficient care consumption. Here we show that the main result goes through if this assumption is not satisfied.

To motivate this case, note that it may not be straightforward for the government to contract with insurers stipulating co-payments  $c_{sk}$ . If insurers would want to over-insure their customers, they could reduce the co-payment indirectly by insuring events that are correlated with state  $sk$ . Hence here we consider the situation where

**GN** the government cannot enforce co-payments  $c_{sk}$ .

Hence  $\gamma_{sk}$  has to be chosen such that it is incentive compatible for insurers to set co-payments in an efficient way.

In particular, in the GN case, setting  $\gamma_{sk}$  as in equation (10) does not guarantee efficient care consumption.

Consider the case where the government reduces the prices of treatment  $k$  in basic insurance to  $\gamma_{0k}, \gamma_{1k}$ . Then risk neutral insurers can offer insurance that induces (ex post) efficient care consumption by specifying a co-payment equal to 0 ( $\Delta v_k$ ) for low (high) quality treatment. With actuarially fair insurance, the premium for such insurance is given by  $\sigma = \theta_k^j(\psi_k \gamma_{0k} + (1 - \psi_k)(\gamma_{1k} - \Delta v_k))$ . Expected utility is then given by

$$U_k^j = (1 - \theta_k^j)v_k + \theta_k^j(\psi_k(\underline{v}_{0k} - \gamma_{0k}) + (1 - \psi_k)(\bar{v}_{1k} - \gamma_{1k})) - \frac{1}{2}r(\Delta v_k)^2(1 - \psi_k)\theta_k^j(1 - (1 - \psi_k)\theta_k^j) \quad (\text{A.11})$$

If the insurer offers full insurance ( $c_{0k} = c_{1k} = 0$  for each  $k$ ) at the actuarially fair rate  $\sigma = \theta_k^j \gamma_{1k}$ , expected utility equals<sup>21</sup>

$$U_k^j = (1 - \theta_k^j)v_k + \theta_k^j(\psi_k \bar{v}_{0k} + (1 - \psi_k)\bar{v}_{1k} - \gamma_{1k}) \quad (\text{A.12})$$

Hence, in the GN case, the government can only induce efficient care consumption if the expression in equation (A.11) exceeds (A.12). This is the case if and only if

$$\gamma_{1k} - \gamma_{0k} \geq \Delta v_k + \frac{1}{2}r \frac{1 - \psi_k}{\psi_k} (\Delta v_k)^2 (1 - \theta_k^j(1 - \psi_k)) \quad (\text{A.13})$$

In particular, if the government sets  $\gamma_{1k} = \gamma_{0k} + \Delta v_k$  this inequality is not satisfied and the supplementary market offers insurance that induces over-consumption.

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<sup>21</sup>Note that it is not optimal for the insurer to induce inefficient care consumption while providing less than full insurance.

A government that wants to maximize insurance subject to efficient care consumption will do the following. It sets  $\gamma_{0k} = 0, \gamma_{1k} = \Delta v_k$  in the GE case. In the GN case it sets  $\gamma_{0k} = 0$  and

$$\gamma_{1k} = \Delta v_k + \frac{1}{2}r \frac{1 - \psi_k}{\psi_k} (\Delta v_k)^2 (1 - \theta_k^j (1 - \psi_k)) > \Delta v_k \quad (\text{A.14})$$

Hence the analysis of the GE and GN case is very similar. In the GN case, the difference between  $\gamma_{1k}$  and  $\gamma_{0k}$  equals  $\Delta v_k$  plus a constant. That is, with GN basic insurance per treatment is less generous (as  $\gamma_{1k}^{GN} > \gamma_{1k}^{GE}$ ). Therefore –with a given government budget– more treatments can be covered under GN.

## B. Using the envelop theorem

When we consider the effects of the government's choice  $(\gamma_{0k}, \gamma_{1k})$ , we focus on the direct effects; ignoring the effects of  $\gamma$  on  $c_{0k}, c_{1k}$ . This is due to the envelop theorem. However, it may not be obvious that the envelop theorem can be applied in this context. The following proposition derives an envelop theorem result in the context of IC constraints. We first introduce some notation.

Let  $u^i(c^i, \gamma)$  denote type  $i \in \{l, h\}$ 's utility as a function of  $i$ 's choice vector  $c^i$  and parameter vector  $\gamma$  set by the government. If type  $j$  mimics  $i$ ,  $j$ 's utility is written as  $\hat{u}^j(c^i, \gamma)$ . Finally,  $\nu^i$  denotes the Lagrange multiplier on  $j$ 's IC constraint not to mimic  $i$ .

In our model the following assumption is satisfied.

**Assumption 1** *Type  $h$  may want to mimic  $l$ , but  $l$  does not mimic  $h$ .*

Then we have

$$U^h(\gamma) = \max_{c^h} u^h(c^h, \gamma) \quad (\text{B.15})$$

$$U^l(\gamma) = \max_{c^l} u^l(c^l, \gamma) - \nu^l (U^h(\gamma) - \hat{u}^h(c^l, \gamma)) \quad (\text{B.16})$$

Now we have the following envelop result.

**Proposition 3** *With assumption 1 we find that*

$$\frac{dU^h(\gamma)}{d\gamma} = \frac{\partial u^h(c^h, \gamma)}{\partial \gamma} \quad (\text{B.17})$$

$$\frac{dU^l(\gamma)}{d\gamma} = \frac{\partial u^l(c^l, \gamma)}{\partial \gamma} - \nu^l \left( \frac{dU^h(\gamma)}{d\gamma} - \frac{\partial \hat{u}^h(c^l, \gamma)}{\partial \gamma} \right) \quad (\text{B.18})$$